Search for two-phonon octupole vibrational states in ^{208}Pb

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For many years the first excited state of ^{208}Pb has been interpreted as a one-phonon vibration of octupole character. The identification of the two-phonon vibration is mandatory in order to prove the vibrational picture and to measure the harmonicity of octupole vibrations. Only recently the first promising experimental evidence for the existence of the two-phonon vibration was observed using a (n,n'γ) reaction, indicating only a slight deviation of an harmonic oscillation [1]. We have performed an experiment to populate the two-phonon vibrational states in ^{208}Pb with ^{154}Sm at a bombarding energy of 1000 MeV and measuring γ-rays in Gammasphere consisting of 60 Ge-detectors at this time. To be independent of the lifetime of the two-phonon state we used a thin target requiring the measurement of the position of the scattered particles to correct for the Doppler-shift of the emitted γ-rays. Scattered particles were detected by a Silicon strip detector covering the range close the grazing angle. Like all previous heavy-ion induced experiments designed to measure the γ-decay following the possible excitation of the second octupole phonon in ^{208}Pb this experiment was performed at a bombarding energy which is about 20% above the Coulomb Barrier. At this energy the nuclear interaction is expected to increase strongly the population probability of the double phonon members [2]. Coulomb excitation as well as coupled-channel calculations indicate that the 6^+ state dominates the population of the multiplet. The decay of the 6^+ state is expected to feed the 5^- state at 3198 keV ($E_\gamma(E1) \approx$ 2MeV) followed by an E2 transition of E_γ=584 keV to the 3^- state at 2614 keV. As can been seen in the partial energy spectrum shown in fig. 1 obtained by gating on the 584 keV transition it is not possible to identify any candidate for the decay of members of the two-phonon octupole vibration. However, based on the efficiency-corrected

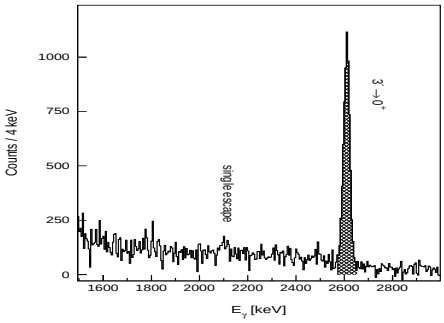

Figure 1: Partial γ-energy spectrum of ^{208}Pb for grazing collisions after gating on the $5^- \rightarrow 3^-$ transition at 584 keV.

intensities we can establish lifetime independent limits for the observation of a γ-transition in a region between 2 MeV and 3 MeV relatively to the $3^- \rightarrow 0^+$ or the $5^- \rightarrow 3^-$ transition. Particularly, the limit for the collisions at the grazing angle are about a factor of 10 below the yield predicted by coupled-channel calculations [2]. However, one has to realize that this limit may not be very sensitive to the population of the two-phonon states since the intensity of the $5^- \rightarrow 3^-$ transition is primarily determined by the decay of energetically higher-lying states, bypassing the higher order vibrational states. Having not been able to observe the decay of any second phonon state it is suggested that we need to perform an experiment at a "safe" bombarding energy well below the Coulomb barrier where only Coulomb excitation takes place as a process which can be described by theory accurately.

References

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